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A new record of the Greek frog at the northern border of the species area

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Abstract

The Greek frog (*Rana graeca*) is a European species, endemic to the Balkan Peninsula. This brown frog inhabits hilly/mountain areas where it almost exclusively spawns in fast-running streams and rivers. The northern border of the species distribution range spreads from northwestern Bosnia & Herzegovina to northwestern Serbia and then shifts towards the southeastern Balkans. The new records noticed in the central part of Serbia (Šumadija) suggest that the presence of the Greek frog could be easily overlooked if a locality is not inspected at the right time of the year. Possible suitable habitats positioned more to the north from the present northern contours of the species area should be thoroughly explored.

Key Words

distribution range, northern edge, *Rana graeca*, Serbia

The Greek frog (*Rana graeca*) is a European brown frog species, endemic to the Balkan Peninsula (Gasc et al. 1997; Sillero et al. 2014; Speybroeck et al. 2016) (Fig. 1A). This brown frog inhabits hilly and mountainous areas where females almost exclusively spawn in fast-running and clear-water streams, springs and rivers, mostly within deciduous and mixed forests (Asimakopoulos 1997); therefore, the survival of its local populations depends on the presence of adequate lotic aquatic habitats and maintenance of the high quality and flow of the water of the respective streams. The Greek frog is globally Least Concern by IUCN criteria in regard to its wide distribution and presumed large population (see Crnobrnja-Isailović et al. 2024a, 2024b). However, this species is threatened by the loss of habitat, the inappropriate and extensive construction of small run-of-river hydropower plants, and, in some places, by pollution from wastewater and mostly small-scale agriculture; additionally, climate change could contribute to the drying of its lotic habitats in the future (Crnobrnja-Isailović et al. 2021, 2024a).

The northern edge of the Greek frog's distribution extends from northwestern Bosnia & Herzegovina (near the Croatian border) to northwestern Serbia, and from there it curves southeast across the country and continues through southwestern Bulgaria (Crnobrnja-Isailović et al. 2024a). In Serbia, the northern border of the species distribution range is not strictly defined by the border between the Peripannonian lowlands and

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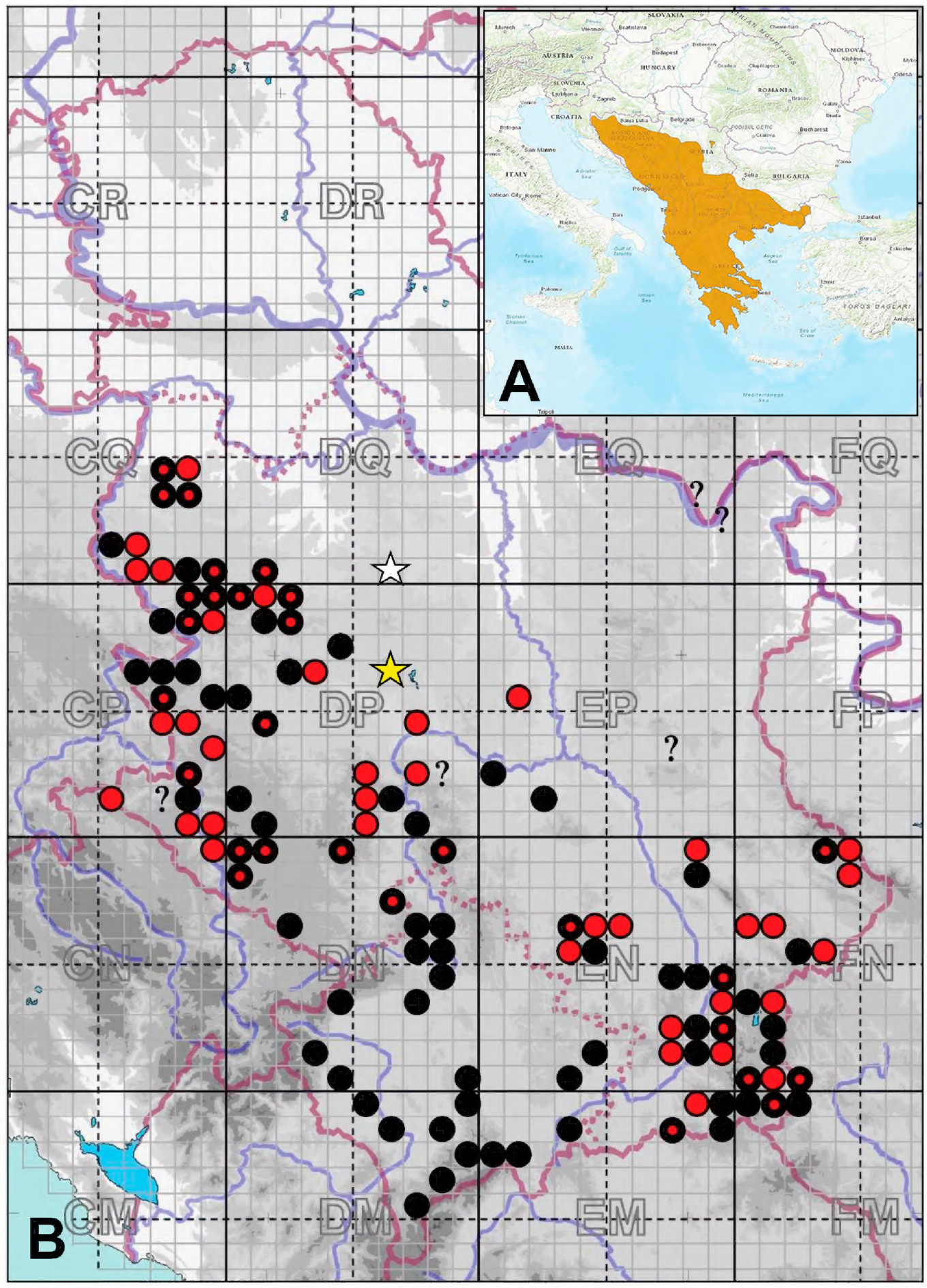

Figure 1. A. Greek frog global distribution. Source: IUCN Red List: https://www.iucnredlist.org/species/58605/229005415; **B.** Greek frog distribution in Serbia, modified. Source: Urošević et al. 2018, doi:10.5937/bnhmb1811227U. Original markings include black circles as published records, red circles as new (field) records, concentric red and black circles as published and field data, and "?" as doubtful field or literature data. The new record is marked as a yellow star in UTM square DP66, while both findings from the AmphibiaWeb online database are located in the same UTM square, DQ60, and are indicated with a white star.

hills and the mountain-valley region (see Marković 1970); according to the literature data, the Greek frog is mostly absent from the large subregion of central Serbia – Šumadija (Urošević and Džukić 2015). Šumadija is contoured by the Sava and Danube rivers in the north, Velika Morava and Zapadna Morava rivers in the east and south, respectively, and Dičina, Ljig, and Kolubara rivers in the west (Jovanović et al. 2022).

Up to now, the northernmost published locality in Šumadija inhabited by Greek frogs has been the Crna Grača River gorge at the foothills of the Juhor Mountain, on the south of Jagodina town – UTM EP15 (Urošević et al. 2018) (Fig. 1B). This northernmost published species record in the mountain region of central Serbia (Šumadija) is positioned farther south than the northern border of the known species distribution area in neighbouring Bosnia & Herzegovina (Šunje et al. 2018) or in western Serbia (Urošević et al. 2018). To date, there have been no published surveys focused on the possible distribution gaps in this part of the Greek frog range. Our new finding and recent records in the public online database suggest that the northern hilly/mountain parts of Šumadija, as well as the entire Eastern Serbia, should be more thoroughly explored for the presence of this species.

Boračka Krš is a tertiary geological formation characterised by a range of elevations from 313 to 515 metres above sea level and positioned between mountains Rudnik and Kotlenik in Šumadija; the vegetation mostly consists of oak forests in the foothills and degraded forest parts and thermophilic meadows in the upper parts, while rocky and chasmophytic vegetation cover the highest parts of this volcanic rock formation (Srbijašume 2019). Boračka Krš has been declared a first-category natural monument in Serbia (Srbijašume 2019). Only a few aquatic habitats were recorded in this protected area: One small water body occurs on the southwestern slope, while Boračka River and its tributary—Boračka Creek—flow along the western-southwestern-southern border of the protected area. We were visiting Boračka Krš from June to October 2024 for the purpose of making a list of protected reptile species in this national nature monument. During each visit, two researchers were applying from two to three visual encounter surveys along predefined routes. In total, there were four visits to the study area—two in summer and two in autumn—with the search starting at 9:00 a.m. and finishing at 3:00 p.m. due to logistic constraints. Regarding the official goals of these field surveys, amphibians were recorded when occasionally seen in the habitat, and no special equipment was used. Additionally, we checked the AmphibiaWeb online database for the records of the Greek frog in Šumadija, submitted after the publication of the research paper on brown frogs' distribution in Serbia (Urošević et al. 2018).

In September 2024, we recorded more than 30 metamorphosed juvenile Greek frogs in the Boračka Creek – UTM DP66, 43.9643N, 20.5962E, 370 m altitude (Fig. 1B). The part of the stream where we have noticed juvenile Greek frogs passes through the edge of the deciduous forest where it is completely covered by the dense canopy. On our next visit to Boračka Krš in mid-October 2024, we recorded a subadult Greek frog at the southwestern slope of the protected area—UTM DP66, 43.9632N, 20.5992E, 400 m altitude (Figs 1B, 2A, B).

Both the Boračka Creek and the Boračka River are located approximately 200–300 metres away from that site.

Two records in the AmphibiaWeb online database, dated from the end of October 2019 and the beginning of October 2020, referred to Bukulja Mt. (UTM DQ60), which is positioned approximately 50 km in a straight line to the north of the Boračka Krš: 44.2828N, 20.5088E (https://www.inaturalist.org/observations/37852667) and 44.2863N, 20.5186E (https://www.inaturalist.org/observations/61404947), respectively (AmphibiaWeb 2025) (Fig. 1B).

Four amphibian species were previously recorded at the Boračka Krš locality: Fire salamander (*Salamandra salamandra*), Alpine newt (*Ichthyosaura alpestris*), Yellow-bellied toad (*Bombina variegata*) and Marsh frog (*Pelophylax ridibundus*) (Srbijašume 2019). It seems that, so far, Boračka Krš was most probably omitted from the systematic batrachology survey, as no data exist about the presence of either brown frogs—*Rana* spp.—or common toads—*Bufo bufo*—there. These early-breeding European amphibian species are widely distributed in this part of the Balkan Peninsula (Kalezić et al. 2015). Those anurans are typically seen in the aquatic habitats only for a short period in early spring during their breeding and spawning season, as the animals are difficult to locate during the rest of the year. Presence of specific egg clutches in small lotic water bodies between late February and the end of March may suggest that the Greek frog inhabits the area. Additionally, monitoring the presence of brown frog tadpoles in fast-flowing rivers and streams from early April to late June could help in tracking the

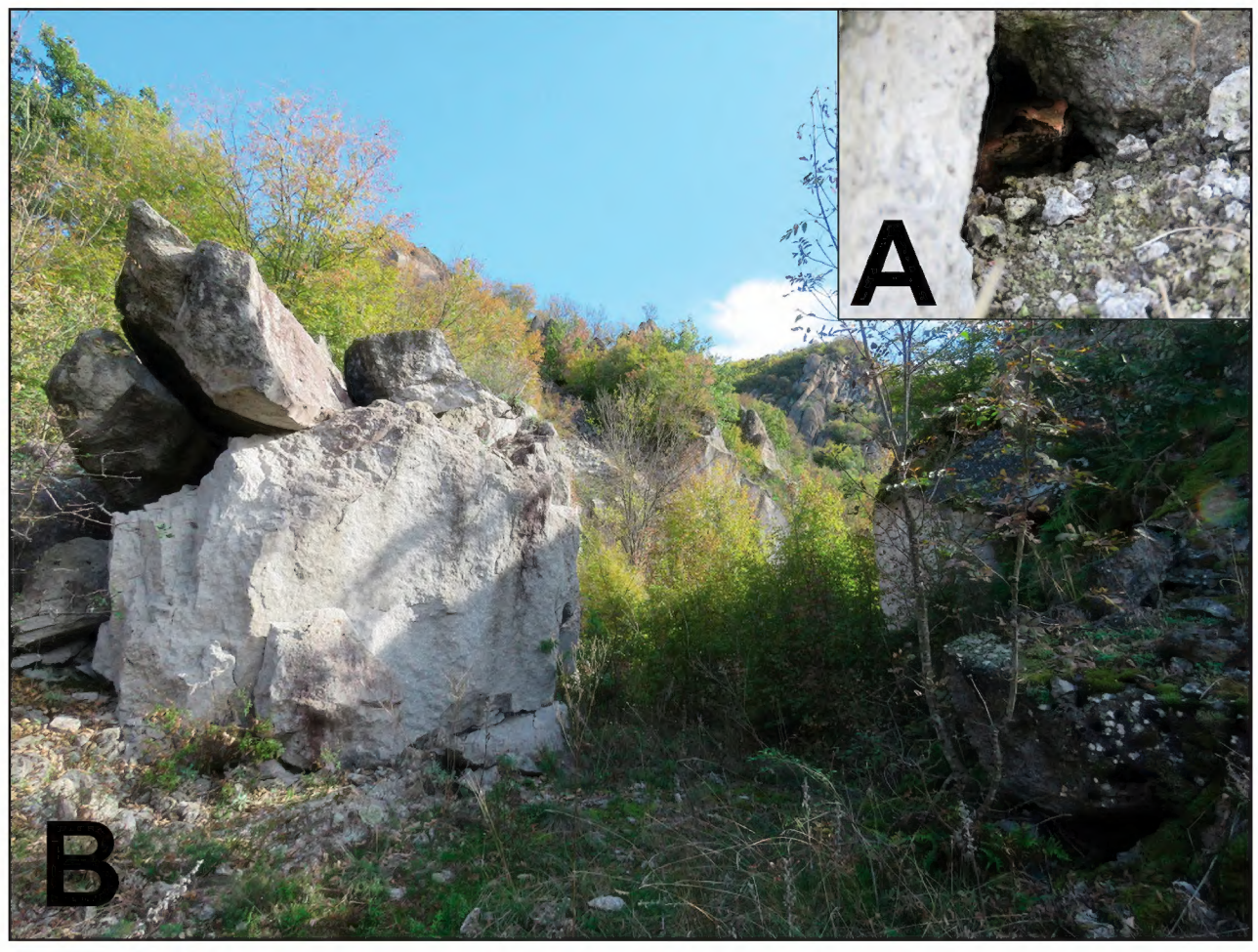

Figure 2. A. Juvenile Greek frog recorded at Boračka Krš in autumn 2024; **B.** Terrestrial habitat where this frog was recorded. Photo: J. Crnobrnja-Isailović.

distribution of this species. However, caution should be had, as the Agile frog—*R. dalmatina*—and the Common frog—*R. temporaria*—sometimes also spawn in lotic waters (Crnobrnja-Isailović et al. 2021).

However, the findings of the Greek frog reported in this study suggest that the northern boundary of the species' range in central Serbia could extend from 10 km to 50 km in a straight line further north than indicated by Urošević et al. (2018). As a result, the mountains north of Borački Krš—specifically, the Gledićke, Kotlenik, Rudnik, Venčac, and Bukulja mountains—warrant thorough surveys to assess the potential presence of this species.

Both Šunje et al. (2018) and Urošević et al. (2018) shared a common view that the obligatory feature of the Greek frog's habitats in Bosnia & Herzegovina and Serbia was the presence of permanent mountain lotic fast and clear water bodies. It is peculiar that this species is absent from habitats located east of the Velika Morava River in Serbia and that the northern boundary of the distribution range there shifts to the southeast of the country (Urošević et al. 2018). In Bulgaria, Pulev et al. (2015) summarised published and new distribution records of the Greek frog, showing that the northernmost localities are situated even further southeast. Far back in 1972, Beshkov noticed the species' absence from a number of suitable habitats in Bulgaria. All these facts indicate the need for further investigation of potential habitats to the north of the current northern boundary of the Greek frog's range.

Recent findings of the Greek frog further north in central Serbia raise the question of whether climate change could be driving an expansion of the species' distribution. Indeed, Jablonski et al. (2021) revealed that certain variables describing temperature and rainfall mostly contributed to the modelling of the distribution of this species and that the overall population has been showing slight growth from the Last Glacial Maximum (LGM) until today, but without significant range expansion. We believe it is premature to draw any conclusions about this potential expansion without long-term monitoring of demographic variables.

Rana graeca is an endemic brown frog of the Balkan Peninsula which inhabits most of its hills and mountains intersected with fast-running rivers, streams and springs. The new finding of this species in the Borački Krš Nature Monument in central Serbia, along with new records submitted to the AmphibiaWeb online database, suggests that the Greek frog may inhabit more northern localities, at least in this region. A more thorough survey of habitats north of the species' current distribution boundary would help refine the size and shape of its distribution range.

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